The financial risks and barriers to electricity infrastructure in Kenya, Tanzania, and Mozambique: a critical review of the academic literature

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The risks and barriers to electricity infrastructure in Kenya, Tanzania, and Mozambique: A critical review of the academic literature

Julian Gregory[1] and Benjamin K. Sovacool*[1,2]

[*] Corresponding Author, Science Policy Research Unit (SPRU), University of Sussex
Jubilee Building, Room 367, Falmer, East Sussex, BN1 9SL
Phone: +44 1273 877128 Email: B.Sovacool@sussex.ac.uk

[1] Science Policy Research Unit (SPRU), School of Business, Management, and Economics, University of Sussex, United Kingdom

[2] Centre for Energy Technologies, Department of Business Development and Technology, Aarhus University, Denmark

Abstract: The recent academic literature contains a number of hypotheses, drivers, or explanations to reveal why electricity infrastructure isn't being developed within sub-Saharan Africa (SSA) in the 21st century. In this paper, we argue that this literature is misdirected, or at least incomplete, in how it approaches risk. We hypothesise that this lack of infrastructure development in the region reflects a lack of investment due to the existence of excessive negative uncertainties or risks – as investment is a function of uncertainty and reward – but that the recent academic literature appears to not appreciate this. To make this argument, we chose a manageable sample of three African countries, which already had a notable body of academic literature concerning them: Kenya, Mozambique and Tanzania. Focusing on these countries, we then undertook a systematic review of 815 'peer reviewed' papers published on the academic libraries of Scopus and/or the Web of Science on the topic of electricity, infrastructure, and risk over a five-year period to see how this literature evaluated the problem. Drawing from the most relevant 101 studies within that sample, we critically examine the methodological, conceptual, and empirical aspects of this literature.

Keywords: Electricity supply; energy poverty; energy access; financial risk; eastern Africa

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1. Introduction

It has been 139 years since Thomas Edison patented his light bulb in 1879; 45 years since Overseas Development Assistance was finalised in 1972; and 17 years since the United Nations Millennium Declaration in 2000. More recent and noteworthy efforts include the Sustainable Energy for All initiative and the announcement of Sustainable Development Goal 7 which deals with energy access (Ockwell and Byrne 2017; International Energy Agency 2017; Gollwitzer et al. 2018). Yet despite these supposedly positive 'milestones' for electricity accessibility, eastern Africa remains one of the world's most electricity deficient regions. According to the most recent data from the International Energy Agency (2018), 75 million people living in Kenya, Tanzania, and Mozambique did not have any access to electricity. From an economic growth perspective, access to reliable and affordable electricity in Africa is a major developmental obstacle [Briceño-Garmendia et al, 2008; Moyo, 2013].

In this study, we argue that the academic community needs a more comprehensive structure for identifying risk. We operationalize risk as including the factors that are material and cannot be predicted, that negatively impact investment in electricity infrastructure, which we call risks or 'negative uncertainties'. To make this argument, we undertook a systematic review of 815 academic studies published on in multiple academic databases on the topic of electricity, infrastructure and risk in Kenya, Mozambique, Tanzania and SSA over a five-year period of 2012 to 2017. Drawing from the most relevant 101 studies within the sample, we investigate the methodological, conceptual, and empirical aspects of this literature.

We find that there is a need to deliver a more useful conceptual framework concerning risk, as well as for creating 'bankable'[1] electricity infrastructure development projects. We argue that new classifications of risk are needed to better understand the financing of electricity infrastructure development than those that exist within the literature. This framework can then be used to influence policy, to support the development of such new infrastructure by the private sector, in the countries of Kenya, Tanzania, and Mozambique.

In proceeding on this path, the primary contribution of this paper is to reformulate the relevance of risk within the academic research community. Admittedly, electricity demand (kWh) is a function of varying contextual factors such as availability of resources, electrical appliance ownership, duration of usage, and the viability of tariffs—all of these impact the innovation ecosystem affecting energy services (Kowalska-Pyzalska 2018). Moreover, there is often a direct or at least meaningful relationship between household economic poverty and energy burdens and energy poverty: the poorer households are, the higher their energy burden, yet poorer households tend to access cheaper energy options when tariffs are high (Sovacool 2012; Monyei et al. 2018a; 2018b; Bohlmann and Inglesi-Lotz 2018).

In an attempt to address energy poverty, the IEA initially estimated that US$389 billion needed to be spent on the development of new sub-Sahara African (SSA) electricity infrastructure, to achieve the UN's Sustainable Development Goal of universal access to electricity for all in the region, by 2030 [Myers, 2013]. More recently, the IEA estimated (2017: 5) that "providing electricity for all by 2030 would require annual investment of $52 billion per year, more than twice the level mobilised under current and planned policies. Of the additional investment, 95% needs to be directed to sub-Saharan Africa."

[1] 'Bankable' – Project or proposal that has sufficient substance, future cash-flow, and high probability of success, to be acceptable to institutional lenders. *www.businessdictionary.com/definition/bankable.html*

Thus, a significant portion of electricity investment will need directed at Kenya, Tanzania, and Mozambique. The only realistic source for the level of financing, that the IEA suggests is required by 2030, is from international financial markets. These international markets consists of pension funds, insurance companies, sovereign wealth funds, and mutual funds (naming the major constituents). Combined, these institutional investors have more than $US100 trillion in assets under management [Arezki, R. et al, 2016]. Harnessing private sector finance therefore offers an incredibly promising but underutilized tool for expanding access to electricity and reducing the extent and severity of energy poverty.

2. Research Design: Risks and Reviews

This paper hypothesises that electricity poverty in Kenya, Tanzania, and Mozambique is caused by the inability to finance the construction of new electricity infrastructure in the region; and this inability is caused by excessive ‘risks’, that surround the development process of electricity infrastructure, that make such development as an investment proposition, unattractive to the private sector.

2.1 Interdisciplinary conceptions of risk

To make this case, we firstly carried out an interdisciplinary review of the literature utilising four separate academic disciplines: investment finance, project management studies, innovation studies, and international development studies. The investment finance literature demonstrates how negative uncertainty or risk in our context, impacts electricity investment in eastern Africa. It utilises the highly-cited theories of Dixit and Pindyck advocated in “Investment under Uncertainty” [1994], as they are the most applicable to the eastern Africa context. The project management literature delivers a framework for identifying and classifying risks, as this forms a major part of that disciplines theory. The innovation literature offers a contribution to theories on the ‘diffusion of technology’ in developing countries

[Rogers, 2003; Abramovitz 1986], as electricity infrastructure development, is essentially a diffusion of technology. The development studies literature emphasizes linkages between energy infrastructure and dimensions such as aid dependence, governance, corruption, and democracy.

From the project management literature, we can see that uncertainty does not necessarily constitute a barrier for such investment, as uncertainty can be a positive when it represents an opportunity [Chapman and Ward 2011; Hillson 2004]. Therefore, the uncertainty that needs to be identified, are the negative uncertainties '*that matter*' [Hillson 2004], which in this paper we will now call 'risk'. Adding to this, there are three further factors that need to be grasped from the literature about how risk can undermine a project's 'bankability': firstly, are the illiquid properties of an electricity infrastructure investment, the investment's value will be tied to the location that the development has been constructed within (the asset cannot simply just be removed and taken away intact) [Dixit & Pindyck, 1994]; secondly, no risks occur in isolation, all risks are interrelated and affect each other; and thirdly, some risks are more significant in their level of impact to a project's deliverables, than others.

The first way to measure a risk's influence, is to evaluate whether it will lead to an absolute or proportional change in outcome; and if it is proportional, to what degree? An absolute change, in this context, is a change that will have binary characteristics – it will alter the outcome completely or not at all. A 'proportional' change, in this context, is an incremental weakening of the expected outcome – but there will still be an outcome. Absolute risks are considered the most dangerous, but only if they are believed likely to happen [Hillson, 2004].

The second way to measure the influence of risk, is in its probability of happening. Some risks are never likely to happen, and therefore can be ignored – for example, a meteor might hit the asset and destroy it (possible, but very unlikely). Others must be empirically predicted, utilising a combination of relevant historical precedents of possibilities and the ability to control or manage human behaviours and the applicable environment. Both these impacts are subjective and are matters of judgement, which means they can be influenced as much by perception as reality. The project management literature usually applies a sliding scale to both these factors [Hillson, 2004]. A high impacting risk that is likely to happen, will always make an investment proposal unattractive – causing it to be rejected.

To help classify the relevant risks, two approaches are utilised. Firstly, a bottom up approach, which separates risk into three separate fields: micro, or project specific derived risk; meso, or country specific risk; and macro, or systematic risk (see Figure 1). As the figure indicates, these risks occur not only across scales, making them polycentric; they also occur to different degrees, with some (construction costs or interest rates) reflecting low risk to project cancellation, whereas others (planning delays, poor exchange rates) reflect high degrees of risk that can scuttle projects, and still others fall between at a moderate or medium degree of risk.

Figure 1: Micro, Meso, and Macro Conceptions of Infrastructure Risk

Note: Micro factors include those at the project or infrastructure level, meso factors national aspects such as regulations or assets, macro factors global dynamics such as exchange or interest rates.

Secondly, a linear approach can be applied to the micro risks, as these are all project specific. Standard project management theory, such as that used by the Project Management Institute, utilises a linear process of distinct management stages in a project's development. Extrapolating from this, we can separate three phases that can be impacted by risk. These are: the planning, the construction, and the operation phases. A comprehensive planning stage will identify the construction and operational risks, as well as instigate remedies to manage them: these aspects have been split, for transparency. Lastly, there is a fourth important class of risk associated with the linear approach, but not specific to a single phase: this is stakeholder risk [Hillson, 2004].

2.2 Systematic literature review

To understand how the current peer-reviewed literature understands the issue of risk, the methodological tool of a critical systematic review was employed. A five-year period was applied to the search, January 1, 2012 until June 30, 2017. Four geographic entities were interrogated: Kenya, Tanzania, Mozambique, and sub-Saharan Africa. Six search strings were utilized and examined in Scopus using the "Title, Abstract, and Keywords" and in the Web of Science applied to "Title and Topic":

1. Electricity and Finance;
2. Electricity and Risk;
3. Electricity and Challenges;
4. Infrastructure and Finance;
5. Infrastructure and Risk;
6. Infrastructure and Challenges.

This search originally delivered 815 studies, but these were reduced to 116 after filtering the title and abstract for relevance. After a detailed review of those 116 papers, fifteen were excluded as not relevant. The 101 remaining papers were then read in full and were analysed and classified according to a coding schema.

The first two attributes coded were about the demographics of the author and the research designs undertaken:

1. Where were authors located geographically?
2. What research methods were employed?

The third through eighth attributes were about the analytical frames and qualitative themes and topics examined, namely:

3. Was access to financing, understood to be the principal cause of electricity poverty?
4. Was uncertainty discussed with reference to financing? If yes, what was its definition?
5. Was risk defined? – If yes, what was its definition?
6. Was 'bankability' discussed?
7. Were policy mechanisms to mitigate risk (such as Power Purchase Agreement or Feed-in Tariffs) discussed?
8. Were barriers to electricity infrastructure development discussed? If yes, what form did they take?

The idea here was that coding these eight categories would best enable a deeper and systematic reflection of the geographies, research methods, and themes being applied in our systematic sample of the academic literature.

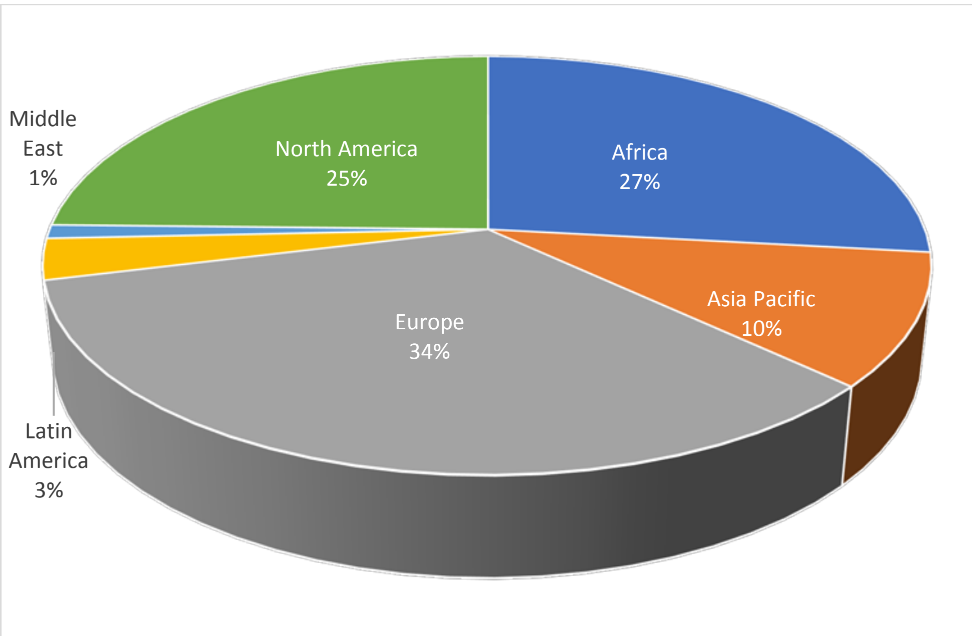
3. Results: Authors, methods, and themes in energy poverty scholarship

This section of the study summarizes our results of the systematic review, under the three broad headings of: author demographics; research methods and designs; and narratives utilised.

3.1 Author demographics

Unexpectedly, our systematic review uncovered that the bulk of research being done on eastern Africa is not done by researchers within east African countries. As Figure 2 indicates, authors at institutions in Europe and North America accounted for a sobering 59% of the sample, with Africa (as a whole) only at 27%. This finding is potentially troubling given it suggests much work is perhaps desk based and/or done at institutions with vested interests in the region (shaped by patterns of colonialism and imperialism). It may also be incredibly hard for African researchers to get published in European scientific journals due to cost and access This becomes even more troubling given our findings about methods, in the next section.

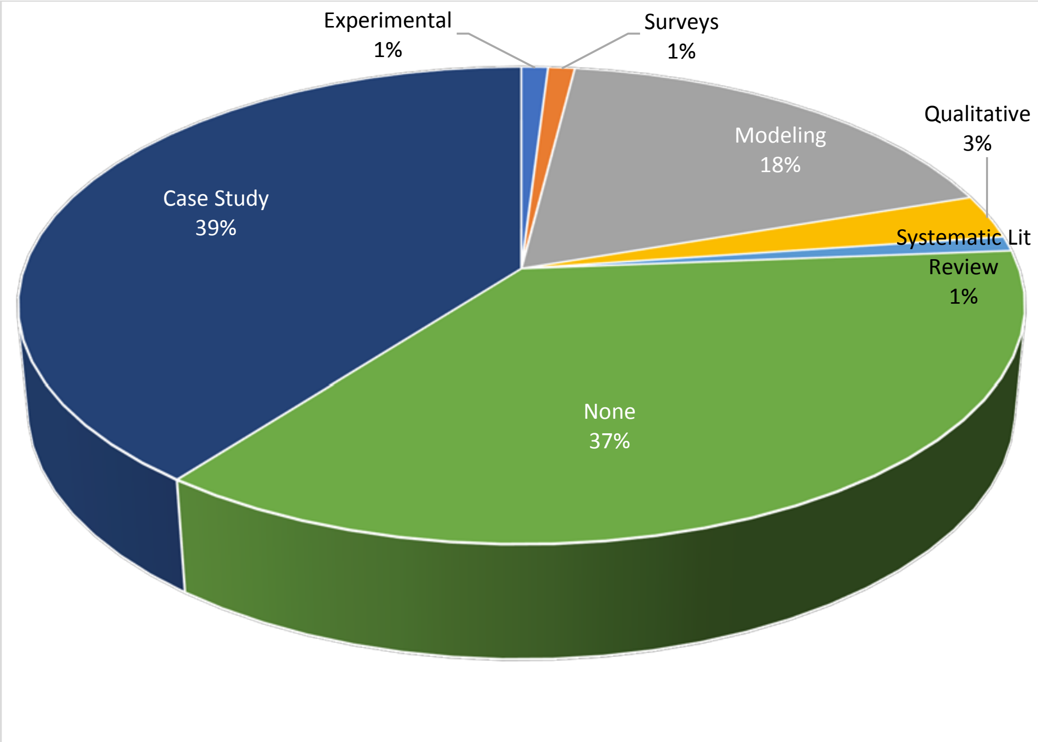
Figure 2: Author Demographics for Research on East African Electricity and Risk, 2012-2017



3.2 Research methods and designs

Figure 3 reveals that while the most popular utilized method among all articles examined was a qualitative geographic case study, the second most dominant method was none at all — studies that had no detectable research design or methods section, commonly a non-systematic (convenience sample) literature review. Indeed, only a fraction of the sample (about 5%) utilized human centred, original data collection methods such as interviews, surveys, or experiments.

Figure 3: Research methods utilized by Research on East African Electricity and Risk, 2012-2017



3.3 Themes and topics

Lastly, and perhaps most problematically, we find that the bulk of papers examined do not meaningfully discuss various elements of infrastructure development risk. As Table 1 summarises below, general risk and the causes or drivers of energy / electricity poverty are more frequently investigated, but access to financing, uncertainty, bankability, and policy mechanisms are not. For instance, only thirteen papers discussed the issue of how to facilitate access to finance, as being the central challenge for resolving electricity poverty [Eberhard, 2017; Chirambo, 2016; Williams et al, 2015; Gujba et al, 2012; Onyeji, 2014; Labordena et al, 2017; Kagimu & Ustun, 2016; Eberhard and Shkaratan, 2012; Eberhard, 2015; Williams et al, 2016; Doorsamy & Cronje, 2015; Ekholm, 2013; Ekouevi et al, 2013].

Only two papers discussed uncertainty, and only one defined it: “the future evolution of relevant parameters, which cannot be derived on past observations” [Tinoco, et al; 2012]. Twenty-nine papers discussed risk, but only five actually defined or conceptualized it: [Labordena et al. 2017; Ogando and Pretorius 2015; Tinoco et al. 2012; Ekholm et al. 2013; and Amars et al. 2017]. Bankability of an electricity infrastructure project proposals was only discussed three times. Types of electricity offtake agreements were discussed only 12 times: The causes of electricity poverty were most discussed, happening in 69 papers.

Table 1: Scope of Themes and Topics and Lacunae in Research on East African Electricity and Risk, 2012-2017

Coding category	**Dimension**	**Number of papers addressing the dimension (n)**	**Number of papers addressing the dimension (%)**
3	Access to financing	12	11.9 %
4	Uncertainty	2	2.0%g
5	Risk	29	28.7%
6	Bankability	3	3.0%
7	Policy mechanisms	13	12.9%
8	Causes of poverty	69	68.3%

Note: Shaded areas represent particularly under-covered areas.

4. Discussion: Frameworks, causality, and risk in energy poverty scholarship

As our systematic review indicates, the discussion of uncertainty and bankability within the literature is artificially narrow, and this appears to be due to the narratives utilised: but with uncertainty, as its meaning can be quite subjective and varied, it could also be that the literature is just focussing on risk as we are.

A public-sector perspective of electricity delivery, is still the default narrative within the governments of Kenya, Mozambique, and Tanzania, as well as much of the academic literature. This is important: as the significance of uncertainty as a variable, and its impact, is completely different between a public and private sector context. Bankability as a variable, is only relevant when applying a private-sector context.

This default perspective of approach, still assumes that a solution to electricity poverty will be driven by a country's government. However, the governments of Kenya, Tanzania, and Mozambique, do not have well-resourced balance sheets [CEPA 4, 2015]: for example, "*Tanzania is one of the biggest recipients of donor aid of which a large share is going to general budget support*" [Amars et al 2016:90]; *Foreign largesse accounts for more than half of Mozambique's national budget"* [Darley, 2012 - citing Bearak, 2009]. Further, due a lack of institutional capabilities [Abramovitz, 1984], each country has a very inefficient tax collection regime, whereby they are not able to cross subsidise their electricity infrastructure through their tax system [CEPA 4, 2015]. This narrative must be adapted therefore towards a private sector one, especially if the private sector is going to be successfully persuaded to finance these three countries' electricity infrastructure expansions.

For privately sourced financing to be forthcoming for electricity infrastructure development in eastern Africa, the risk landscape must be able to fit within acceptable parameters. If it doesn't, such investment will not be accepted as an attractive commercial proposition – it will not be considered as 'bankable'[2] – and there will be no 'private sector' participation.

Therefore, we encourage academia to change its approach and become more consequentialist.

4.1 There is a need to widen electricity poverty themes, topics, and narratives

When a theoretical explanation for electricity poverty in our review is presented, most papers adopt one of two systems approaches.

[2] Bankable – see reference, page 6.

4.1.1 A Socio-technical Systems narrative

Twenty-nine papers within the systematic sample, adopt a 'socio-technical' narrative [Geels, 2004]: that attributes the problem of electricity poverty, to a lack of demand. This narrative suggests that within the three countries being analysed, there is a lack of household income (a social constraint), which limits demand for electricity as it cannot be afforded. This lack of demand in turn undermines the commercial basis for a supply of electricity from larger scale electricity infrastructure – the grid – resulting in a continuance of the electricity poverty. This narrative, views finance as a limiting constraint that restricts the range of solutions to electricity poverty – much like the hours of sunlight are a constraint in generating solar electricity, or water hydrology is a limitation to the generation of hydroelectricity.

Solutions for electricity poverty within this narrative, are therefore built around which technologies are possible to deliver electricity, within this financially constrained environment. In the papers included in the systematic review, this usually involves the utilisation of small scale distributive generation technologies [Ackermann, 2001], such as micro-grids powered by either small scale photo-voltaic solar (PV) or Pico-hydro[3] [Brix Pederson, 2016; Hofmeister, 2015].

4.1.2 A National systems of innovation narrative

Alternatively, twenty-four papers adopt a 'supply side' narrative that is determined by a 'national systems' theoretical approach [Freeman, 1995; Lundvall, 1985]. This perspective generally explains electricity poverty in eastern Africa as being the consequence of an inefficient and dysfunctional delivery system: in the form of the country's electricity utility and surrounding government institutions [Eberhard and Shkaratan, 2012; Amars, 2016]. This

[3] **Pico hydro power**: Turbines **smaller than 10 kW** are usually called "Pico". Pico hydro power is rarely fed into a power grid, but in most cases, electricity is delivered to a village or a workshop. https://energypedia.info/wiki/Pico_Hydro_Power

dysfunctionality arises out of a poor structure of governance that each country's electricity utility is exposed to, which when coupled with a lack of institutional capabilities [Abramovitz, 1984] and combined with other factors: prevent the supply of affordable and reliable electricity.

The core of this theory is that each utility is not able to recover its cost of generating electricity, when it sells it. This can be for number of different reasons, but the most common ones given by the literature are:

- The retail tariff is to low [Eberhard and Shkaratan, 2012].
- There is a significant loss of electricity in the transmission system – as high as 25% in Tanzania [Amars, 2016] – before it reaches the customer;
- Or customers just don't pay their bills [Eberhard and Shkaratan, 2012].

A combination of these factors, means that the utility is close to insolvency, and only manages to keep operating with ongoing government subsidies - which are never enough. This troubled condition then has a knock-on effect, due to too few resources to maintain and operate the system efficiently: there are no spare parts, and the infrastructure just wears out [Amars, 2016].

We advocate that both these narratives are too limiting in their explanation of the challenge.

4.2 Appreciate the relevance of causality

Even though both these narratives acknowledge that finance is a barrier to electricity access within the region, and in that sense in general agreement with study, they differ from our premise in their perspective of causality and the centrality and significance of this financing restriction. We postulate that electricity poverty in eastern Africa, is as much an issue of causation as it is about the underlying challenges that impact access to electricity: what causes what to happen, rather than just a sum of everything.

Further, the ability to finance is a dependent variable that is determined by the many challenges (risks) that are listed in the literature, which are all independent variables. The dependent variable of finance, determines the severity and nature of impact of all the other challenges. To apply an analogy: the issue of electricity poverty in eastern Africa is like a large funnel that has a wide top and narrow neck. At the top, we can place all the uncertainties that negatively impact on electricity infrastructure financing, that are listed within the academic literature (these are our independent variables). The 'neck of the funnel', represents the ability (or inability) to finance the building of new electricity infrastructure (a dependent variable).

We can potentially widen the neck of the funnel by either: managing the current independent variables, by reducing their risk; or by being able to redefine the independent variables, by changing them for something with less uncertainty. As an example: governance issues surrounding the development of electricity infrastructure in eastern Africa, primarily undermine the ability to finance such development, rather than the development process directly.

4.3 A better understanding of risk

Further we argue that the academic community must come to more dynamically assess (and grapple with) risk. We give six examples of different dimensions of risk that require more rigorous analysis: planning risk, construction risk, operational risk, stakeholder risk, meso or country risk, and macro or systemic risk (with Table 2 offering an overview summary). In this classification, we have utilised a limited amount of additional academic and grey literature for citation purposes, to fill evidence gaps in the systematic review literature.)

Table 2: Overview of risks to electricity financing in Sub-Saharan Africa

Category of risk	**Description**	**Degree**
Planning	Planning, licensing, or approval costs and delays	High
Construction	Engineering, procurement, and construction costs for both fossil-fuelled and renewable electricity infrastructure	Low
Operating	Unexpected changes in performance, credit, regulation, or security	High

Stakeholder	Individual, group, or organisational actors that can affect a project	Moderate
Meso/country	Changes in capabilities, policy regimes, governments, or complimentary assets	High
Macro/international	Global interest rates, appetite for long tails, or exchange rates	High

4.3.1 Planning risks

The two principal negative features connected with the planning of infrastructure in the region, are related to the amount of time taken (an associated cost), and the actual cost of dealing with the level of red tape, that surrounds the infrastructure development process in all three countries. Both these issues are closely related and will be dealt with together. They stem from the lack of institutional capabilities, which our sample country suffer from, and governance issues [Collier, 2014; Amars et al, 2017]. The lack of institutional capabilities, result in macro sociological and institutional barriers, which prevent the successful adoption of new technologies by a less developed economy [Abramovitz, 1986]. These arise from deficient skills, processes, and knowledge, which prevent the successful diffusion of technology, which is what electricity infrastructure would qualify as.

The infrastructure planning process for electricity in eastern Africa, is considerably more risky and costly than its OECD equivalent. Planning costs can be as high as 10% of the project value, in contrast to the OECD standard of under 1% [Castalia; 2014:21]: partly due to a lack of available of institutional expertise within the government, but also mischievousness 'rent-seeking' [Krueger, 1974] from politically connected individuals, who use their 'power to delay' to extract an 'advantage', particularly in Tanzania and Mozambique [Amars et al, 2017; Kihwele et al, 2012; Darley, 2012]. It can also be very difficult and expensive for an international investor, to obtain the necessary expertise that is appropriate for each country.

This absence of institutional capability and governance, adds to the planning costs in two ways, as the government is responsible for both creating and authorising infrastructure schemes

[CEPA 1, 2015]. Poor institutional capability within government, results in a deficient formulation of tenders, as there is little comprehension of investor prerequisites – for example, there are no set standards for structuring projects: "*the supporting legal documentation for the off-take agreement in a recent Kenyan electricity project was a thousand pages long, resulting in prohibitive costs*" .... "*The equivalent in India would likely be only 20 pages*" [Collier; 2014:40].

There is also a lack of capacity to swiftly evaluate the requisites and suitability of a project proposal and its accompanying documentation, largely due to a bureaucratic structure, where a complicated administrative process stalls everything (even without mischievous motivations). The Lake Turkana wind farm project in Kenya, the largest in Africa, took far longer to reach financial close than would be normally expected in other, more developed jurisdictions [CEPA 2, 2015]. The total number of proposals also overwhelm the bureaucracy, many of which are unsuitable for purpose. Kenya is better in this area than Mozambique and Tanzania, where its governance is improving [CEPA 2, 2015].

We give these risks a **high rating**: despite these risks being proportional, we give them a high rating because they can stop an investment evaluation from ever happening, and they a high probability of occurring.

4.3.2 Construction risks

Construction risks are negative factors that are attributable to the physical construction of an electricity infrastructure asset. These can be reduced into two elements: the technology being utilised within the asset; and the contractor that is responsible for the asset's construction.

Technology risks surround the implementation and operation of the relevant technology to be utilised to generate electricity, which we subdivide into the traditional fossil fuel technologies and renewable technologies. We note the strong academic debate over which technologies should be utilised when developing electricity infrastructure in eastern Africa, due to climate change. To reflect this as well as for clarity of explanation, as both technology risks have different causalities, each will be reviewed separately.

Fossil fuel technologies are better understood in SSA and therefore aren't regarded as problematic – as such, they are easier and cheaper to finance. They are however more expensive to operate, due to their need to obtain feedstock (coal, oil, etc.); and this is a burden not just because of the cost of the fuel, but also because that requires 'hard' currency (This will be discussed later under currency risk, which will be within the macro-risk section). Currently diesel generation is the major fossil fuel utilised for this reason, as it is the most flexible and cheapest technology to install, despite being the most expensive to operate, when compared to other technologies on a variable cost basis [Eberhard and Shkaratan 2012; Labordena et al, 2017]. Mozambique has proven rich coal reserves, and all three countries have likely offshore gas reserves. These are yet to be fully exploited however, as governance issues are slowing the progress of this development [Robbins and Perkins, 2012]. The existence of this resource has created a bias within Mozambique and Tanzania towards fossil fuels, particularly as they don't yet see climate change as being an African issue [Amars, 2017; Kihwele et al, 2012].

Different **renewable technologies**, differ in their risk profile, which makes it necessary to split traditional hydro from: modern geothermal, solar and wind technologies. Hydro technologies, have been the backbone of all three countries electricity systems since their colonial independence, after being installed by each country's previous colonial administrations. Each system is suffering performance issues however, through poor maintenance [Eberhard & Shkaratan, 2012]. The technologies future in the region is now also very questionable, due to climate change which has negatively impacted the regions hydrology and completely upset the technology's viability – particularly in Kenya and Tanzania [Eberhard & Shkaratan, 2012; Amars 2017].

The unique hydroelectric arrangements in Mozambique deserve special note: Cahora Bassa is the country's principal hydro dam (which is located on the Zambezi river), which is responsible for over 95% of the country's electricity generation. Over 90% of the electricity generated from this dam is exported, as this was a necessary requirement to finance the facilities construction [Isaacman, 2015]. This issue clearly demonstrates, the compromises that finance issue can lead to in the region.

The risks surrounding other renewable technologies can be attributed to a high fixed upfront cost which makes financing more expensive; and issues of capabilities when it comes to construction, operation, and servicing - as these are new and unfamiliar technologies that require expensive overseas trained labour forces. Expensive foreign expertise will have to be hired in, to implement the new technologies, but this can then create issue of friction politically with stakeholders, particularly over the longer term, as the client countries demand the utilisation of a local workforce. This can also lead to security issues (see below) [Eberhard & Shkaratan, 2012]. This then creates long term performance risk, another important factor in being able to obtain finance [Labordena et al, 2017].

In conclusion: both the governments of Tanzania and Mozambique favour the use of fossil fuel technologies, for the development of electricity generating infrastructure, as they have lower development costs and associated complications than renewables. Kenya, which is far more sympathetic to climate change, favours the use of renewables, particularly geothermal [CEPA 2, 2015]. The academic literature, as witnessed in the systematic review, has a definite bias towards the use of renewable technologies for the future of electricity generation in eastern Africa – due to the above technology familiarity and lower financing costs, this debate cannot be regarded as a settled [Labordena et al, 2017].

Contractor risk encompasses whether a contractor that is constructing the asset on behalf of the investor, can fulfil their contractual obligations: in terms of robustness, quality, cost, and timeframe – that has been itemised and accepted in the contract. If the contractor has experience in the region and the technology to be utilised, these risks should be proportional and of a low probability – but eastern Africa is a very challenging environment.

It is standard practice for contractors to give performance guarantees with their work, within their contractual arrangements. There are also many financially well-resourced engineering firms, that are interested in carrying out such work – so if proper ‘due diligence’ is carried out when appointing a contractor, this will minimise such risk.

Together, we give these risks a **low rating**: despite these risks being absolute and having a high impact, the option of **choice** of both technology and contractor allows for both risk transfer and avoidance.

4.3.3 Operating risks

Operating risks directly influence the revenues of the new infrastructure, once it has been commissioned. They can be sub-divided into four groups:

- Performance - will the technology function in the way it was engineered to do;
- Credit - will the anticipated buyer of the electricity, pay the anticipated price in a timely fashion;
- Regulation – will the assets expected output and tariff, be free of inappropriate political interference;
- Security - will the asset’s essential personnel be safe from physical interference, and will the physical asset be safe from theft and vandalism/terrorism.

Performance risk has already been discussed as part of *technology risk* in the previous section: so, this will not be analysed further here.

Credit risk in each country, can be attributed to each country’s electricity utility’s ability to pay its bills. All three country’s utilities have monopoly rights to distribute electricity to customers in terms of the main grid [CEPA 2&3, 2015; Amars 2017] (where larger scale customers will be located), so this requires accepting the country's utility as the customer for any electricity generated – but none of these utilities has an investment grade credit rating, and therefore able to be considered a credit worthy counterparty [CEPA 2&3, 2015; Amars 2017; Eberhard & Shkaratan, 2012]. A standard way around this, is for the actual government to offer guarantees, but Kenya only offers these sparingly – it partly did so with the Lake Turkana wind farm project – and both Tanzania and Mozambique have both refused to do so [CEPA 2&3, 2015; Amars 2017]. This poor credit rating, also makes the credit management tool of 'Power Purchase Agreements' (PPA) in this environment ineffective [CEPA 4, 2015].

Regulation risk in all three countries is expressed through tariff restrictions, because of political lobbying, particularly from business, to keep electricity prices low [CEPA 1, 2015; Eberhard & Shkaratan, 2012]. These tariff rates are currently below the cost of generation – so when you consider there are substantial losses of electricity in the transmission process, 25% in Tanzania [Amars, 2017]; and a significant failure of customers paying their bills [Amars, 2017; Kihwele, 2012; Eberhard & Shkaratan, 2012] – this is a major negative factor for investment.

The only reason each utility is still solvent, is through government subsidies from general revenues (and aid): therefore, whilst tariff limits are in place, any increase in access to each country's grid, will put further financial pressure on each governments balance sheet (particularly as the incremental cost of the new supply, will be much higher than the existing supply) [Eberhard & Shkaratan, 2012]. It should be noted, that this is a policy that favours the country's urban elite, as the rural poor don't have any access to electricity that is subsidised [Eberhard & Shkaratan, 2012: citing World Bank and Fritz et al 2009].

Security risks are factors that impact both the asset and key staff. Assets can be damaged through acts of terrorism or criminality; key staff are increasingly under threat of kidnapping for ransom. Some examples would be: in Mozambique RENAMO, the country's political opposition and past civil war adversary, have threatened to resort again to conflict[4], although they did sign another peace agreement in May 2017 (during the country's civil war post-independence, when RENAMO was a party to the conflict, the Cahora Bassa transmission infrastructure was continually attacked by them [Isaacman, 2015]); in Kenya, transmission infrastructure is continually vandalised, particularly by aggrieved stakeholders, or has electricity stolen from it; key personnel are subject to kidnapping [Gumbe, 2016].

We give these risks a **high rating:** both impact and probability are high, due to the likelihood of the four sub-factors working in combination.

4.3.4 Stakeholder Risk

Stakeholders in our context, are any significant individual, group, or organisation: that has both an interest and an ability to influence the development of an electricity infrastructure project [Hillson, 2005]. Stakeholders influence is not necessarily specific to any stage of the development process, and they can either be proportional or absolute in their impact, depending on the level of power and willingness to wield it. A relevant government minister could be absolute in impact, if they chose to nationalise an asset for instance; a bureaucrat could be very troublesome, but in a more measured way. Examples of stakeholders include: senior government ministers, government bureaucrats, infrastructure effected populations, business customers, residential customers and donors. Their capturing qualification is that they are all impacted in some way by the existence of electricity infrastructure, all have a legitimate interest in its operation, and they also have the ability to negatively impact it if they feel the need to do so. Therefore, if they are not appreciated and managed, they can be very troublesome [Hillson, 2005].

[4] Connection within the country quoting local press

Many of the stakeholder issues will be covered under meso-uncertainties in the next section, under political risk.

We offer a **medium+ rating** for these risks: their impact is proportional and medium, but the probability is high.

4.3.5 Meso or country risks

This 'field' of risk are specific to a country and its institutional and social structures, which are often to do with issues of governance. Four primary meso risks exist: capability, legal/regulatory, political, and complimentary assets.

Capability risk has already been partly reviewed within planning uncertainty, and the other aspect of this will be assessed in the macro risks section, in how it creates exchange rate structural risks – so these risks will not be analysed further here.

legal/regulatory risk have been mostly covered already in earlier sections, and are fairly intuitive in nature, so these risks won't discuss further.

Political risk are primarily issues of governance that arise from neo-patrimonialism, which is a predominant governance model to SSA. The governing elite's need to finance a political patronage system to maintain control of the political structure that delivers benefits to those that administer it [Bratton & Van de Walle, 1994; Erdmann & Engel, 2006], brings about acts of financial misappropriation through informal 'rent-seeking' [Krueger, 1974], which is facilitated by an abuse of asymmetric power. The electricity infrastructure business model is not sufficiently robust when faced with any sizable rent-seeking, due to the already discussed acute tariff regulation, and is vulnerable to becoming un-commercial when consistent illicit demands are placed upon it. As foreign investment in SSA is normally associated with the high 'rent' carrying business models associated with resource extraction, it is unclear how comprehensively SSA ‘policy actors’ appreciate this financing vulnerability (or care) that is applicable to electricity infrastructure projects.

We give these a **high-risk** rating, as neo-patrimonialism is embedded in each country’s political system, and the business model of electricity infrastructure is not robust enough to absorb any illicit payments.

Complimentary assets [Teece, 1986] are structural factors, which are essential for enabling the electricity infrastructure to create and appropriate value. They can be absolute or partial in their impact, as without them the principal asset would not be able to operate effectively. They are often physical assets but can also include structural processes.

The most significant of complimentary asset issues result from the imbedded nature of electricity infrastructure. Unless a small-scale distributive technology is being utilised (such as home solar), electricity infrastructure can be divided into three separate components: electricity generation, the creation of electricity from an alternative form of energy such as wind (kinetic energy) or coal (potential energy); electricity transmission, the grid that utilises pylons and wires; and local area distribution, the connectivity between the closest electricity substation and home. It is not just the existence of these separate components, but also how effectively they are operating that makes them complimentary to each other.

In all our three countries, as already mentioned earlier under the operational uncertainties, the transmission infrastructure and local area distribution is the responsibility of the country’s national utility. The commercial viability of these utilities is questionable and the performance of the transmission assets unreliable, Tanzania loses 25% of the electricity generated through its transmission infrastructure [Amars 2017]. This makes the uncertainty that surrounds the availability of efficient complimentary infrastructure in eastern Africa, substantial – even when/if they are promised during planning.

Further examples of complimentary assets would be: effective hydro generation requires water sources to be dammed and flooded, with effected populations to be relocated; a solar photo voltaic (PV) power station necessitates that its PV panels are not stolen; an efficient tendering process requires standardised and comprehensive paperwork, which efficiently sets out required guidelines; effective payment for electricity used, requires an effective billing system.

We give these risks a **medium rating**: responsibility for their supply relies on the country's institutions and the commerciality of any new infrastructure is completely reliant on it – however, as these risks can be identified in advance and planned for, risk factor should reflect this.

4.3.6 Macro or international systematic financial risk

In our three countries, the domestic banking system is mostly too undeveloped to finance any significant value of electricity generation infrastructure projects, Kenya has enjoyed some success however [CEPA 2, 2015]. Therefore, for private sector to finance infrastructure, it will require facilitation from the international financial markets. This will then expose electricity infrastructure development, to international systematic financial risks.

There are three key variables that need to be appreciated from this risk field. First is international interest rates - which will determine the rate of return the investment will demand. Interest rates affect all private sector investments in that they determine the 'benchmark cost' that finance will be available for infrastructure development. On top of this 'benchmark', is then added the risk premium demanded for the country and project uncertainty – known as the Weighted Average Cost of Capital (WACC)[5]. If both these figures are high (assuming there is

[5] WACC - Weighted average cost of capital (WACC) is a calculation of a firm's cost of capital in which each category of capital is proportionately weighted, to represent its relative risk to its alternative uses and its absolute risk profile.
http://www.investopedia.com/terms/w/wacc.asp

still a willingness to finance within eastern Africa), this required return is likely to be too great, for the underlying commerciality of the project.

Second is a long tail appetite, the financial markets inclination to hold long dated illiquid investments. This is a measure of the sentiment of the financial markets: whether they are ‘bullish’ or ‘bearish’, to use a ‘markets’ cliché. Infrastructure investment by the private sector, requires long time horizons to function: usually more than 20 years. If the markets are bearish (pessimistic), it is unlikely that market sentiment would enable long-dated investments in eastern African electricity infrastructure to occur. As a ‘rule of thumb’, the more bullish (optimistic) the markets are, the more willing they are to finance such investments.

Third is exchange rate risk, or how much value is potentially at risk, in the repatriation process of the value of the investment. Our three country’s currencies are classified as ‘soft’, which means they are illiquid and not easily transferable in large value transactions; this creates a significant negative uncertainty for the revenues to be received in the borrowed hard currency, which can be reduced sizably from the nominal level during the conversion process, obstructing the willingness to finance. This issue can then be compounded by exchange controls, which prevents any repatriation of money from the country. Mozambique currently has such restrictions, where unless the funds have been earned through export, they cannot be repatriated from the country [Amars, 2017]. Domestically orientated electricity infrastructure, would be impacted by such restrictions.

Clearly, the threat of not being able to repatriate funds, is an investment killer – as this removes both the ‘future rewards’ of an investment as well as destroys its initial value. This is a factor that is rarely considered by the development literature – exchange risk was only mentioned in 6 of the 101 papers reviewed as part of the systematic review.

We give these risks a **high rating**: the three factors in combination will ultimately determine whether an infrastructure project can be internationally financed.

5. Conclusion and policy implications

This study accepts that causes behind electricity poverty in eastern Africa are many and complex, with many variables negatively impacting the delivery of electricity in the region. Rather than supposing that the obstacles identified in the literature result in electricity poverty directly, instead we argue that they are independent variables that control the ability to finance the construction of new electricity infrastructure – their impact is therefore indirect. This means that a standard systems narrative is an incomplete explanation of electricity poverty, which instead needs to be broadened to include uncertainty and its impact. In sum: the academic community, and the policy regimes that it informs, needs to adopt a more complex and dynamic approach to financing electrification.

Further, our study notes a lack of authors writing on this subject are located within eastern Africa (only 27% of our sample), and a paucity of human centred methods (fewer than 5%) such as original data gleaned from interviews, surveys, experiments, and other stated preference techniques. Worryingly, more than one-third of articles (37%) examined had no formal method at all. This suggests the energy studies academic community needs more inclusive yet robust and rigorous research, a finding also noted by Sovacool (2014) and Sovacool et al. (2018).

Lastly, as evidenced from our systematic review, much of the development literature sees the financing of electricity infrastructure in eastern Africa as a fixed and limiting constraint, that is limited by low household incomes – much like the hours of sunlight are a constraint in generating solar electricity, or water hydrology is a limitation to the generation of hydroelectricity. Instead, we argue that the ability to finance is a limiting factor, whose confines can potentially be alleviated when they are fully understood and then managed. As such, they are potentially resolvable or at least relievable.

Moving forward, our study points the way to some compelling research gaps. One is translating our qualitative findings into quantitative energy models or data analysis. Surely, economic poverty, electricity demand, and electrical appliance ownership (to name a few) affect financing. Such qualitative factors could be factored into future models seeking to understand the connection between economic poverty, electricity demand, political tensions amongst others and financing. Furthermore, while conceptualizations of risk, bankability, and uncertainty appear to be scant within most academic energy policy literature, discussions of those themes outside the academy, especially in the public sector or within development banks and multilateral financial institutions, seems to be more robust. If so, more transdisciplinary work is needed that bridges professionals and practitioners of development finance with academic scholars working on electrification and poverty.

For if this understanding of the causes of electricity poverty in eastern Africa can be appreciated and be incorporated into policy, then meaningful progress can be made in reducing this electricity poverty. This is the goal of this study: to redirect the policy debate, so that finally the eastern African region can enjoy access to reliable and affordable electricity, and consequently meaningful economic growth.

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